Issue 1 . 2021 / March

PRO LOEWE NEWS

The LOEWE Research Initiatives report

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Title: LOEWE-BAMP! scientists are using their research work to qualify paper for use in the construction industry. As a renewable raw material, it could make a significant contribution to sustainability, particularly in this sector. They have now been invited to attend the Venice Biennale of Architecture with their project.

LOEWE

Excellent Research for Hessen's Future

FOUR NEW LOEWE PROJECTS ATTRACT RESEARCH FUNDING

Four new LOEWE clusters in Hesse have been receiving state funding since 1 January 2021. The LOEWE Administrative Committee decided which ones based on the assessments of independent, outside experts and the recommendation of the LOEWE Programme Advisory Board. The research projects will receive funding from the state programme amounting to EUR 17 million over a period of four years.

LOEWE WhiteBox. Humans and AI – mutual „understanding" of intelligent behaviour. Photo: sdecoret/stock.adobe.com

LOEWE PriOSS – Principles of surface-supported synthesis strategies

How can fundamental models for surface-supported synthesis be developed? Complex nanostructures such as graphene nanoribbons could be used as electronic devices in the next generation of microchips and quantum computers. Scientists have discovered that fabricating these nanostructures directly on a surface, known as surface-assisted synthesis, is very promising and opens up new possibilities. Physics and chemistry researchers now want to develop basic mechanistic models of surface-supported synthesis within the **"PriOSS – Principles of surface-supported synthesis strategies" LOEWE cluster** and thereby create a "toolbox" similar to the one that has existed for the classical synthesis of molecules in solutions for a long time.

Spokespersons: Prof. Dr André Schirmeisen and Prof. Dr Herrmann A. Wegner. Project partners: Justus Liebig University Giessen (lead), Philipps-University Marburg.

LOEWE WhiteBox – Explicable models for human and artificial intelligence

Artificial intelligence (AI) has become an integral part of our everyday lives: voice assistants, navigation systems or music streaming services are just a few examples of AI systems that we all use on a daily basis. The technology has now developed to such a degree that artificial intelligence can even surpass human intelligence, for example, in games of chess or poker. However, even scientists are often at a loss to understand how AI systems "make their decisions". In many areas where AI is used, however, comprehensible and reliable predictions are essential – for example, in medical diagnostics. As a result, the **"WhiteBox" LOEWE cluster** is seeking to develop methods that derive comprehensible explanations from human or machine behaviour.

Spokespersons: Prof. Constantin Rothkopf and Prof. Kristian Kersting, Technical University of Darmstadt.

LOEWE Diffusible Signals – Impact of diffusible signals at human cell-microbe interfaces

How do bacteria and human inflammatory cells communicate? Bacterial infectious diseases are one of the most frequent causes of death around the world. Antibiotics have become an established and successful way of treating bacterial infections. However, they are becoming increasingly ineffective due to resistance. A team of physicians, biologists and computer scientists within the **"Diffusible Signals" LOEWE cluster** is seeking to investigate the exchange of soluble (diffusible) signals at the interfaces of clinically important bacteria and inflammatory cells, which play a key role in determining the course of any infection. This should enable them to better understand and influence the key elements in infection processes. New results could help develop targeted therapies to treat bacterial infectious diseases.

Spokesperson: Prof. Dr Bernd Schmeck. Project partners: Philipps-University Marburg (lead), Justus Liebig University Giessen, Max Planck Institute for Terrestrial Microbiology, Marburg.

LOEWE iCANx: Cancer – Lung (Disease) Crosstalk: Tumour and Organ Micro-Environment

Cancer is a global challenge: the disease significantly reduces both patients' quality of life and their life expectancy. The progress of the disease and mortality depend on the interaction of tumour cells with their environment. The **"iCANx: Cancer – Lung (Disease) Crosstalk: Tumour and Organ Micro-Environment" LOEWE cluster** is aiming to investigate how tumour cells adapt to the successful colonisation of the lung to its organ microenvironment and reprogramme it as well as how diseases associated with lung cancer, such as chronic obstructive pulmonary disease (COPD), pulmonary hypertension and pulmonary fibrosis, influence this. New insights could enable the development of innovative therapeutic and curative approaches, which, for example, prevent metastases from colonising the lungs.

Spokesperson: Prof. Dr Till Acker. Project partners: Justus Liebig University Giessen (lead), Philipps-University Marburg, Max Planck Institute for Heart and Lung Research, Bad Nauheim.

BAMP! LOEWE CLUSTER PRESENTATION ON BUILDING WITH PAPER AT THE 17TH VENICE BIENNALE OF ARCHITECTURE

The scientists involved in the **BAMP! LOEWE cluster** at the Technical University of Darmstadt have received a very special award: they have been invited to present the results of their research project at the 2020/2021 17th Venice Biennale of Architecture.

The Biennale has already been postponed twice due to Covid-19, but now the time has finally come and the scientists in Darmstadt are preparing the BAMP! exhibits for their journey to Italy, where they will be on display in the exhibition rooms of the European Cultural Centre from 22 May until 21 November 2021. The exhibition at the Palazzo Mora is called "Building with Paper" and the aim is to draw visitors' attention to the possibilities of using paper as a special and sustainable building material in architecture. According to the exhibition concept, visitors to the Biennale will enter a room where the walls have been entirely wrapped in paper or cardboard. The exhibits as well as the cladding on the walls are made entirely of paper materials. Honeycomb panels, for example, pick up the ornamentation of the Italian Renaissance and transport it to the material, paper. This transfer of a classical architectural language to the new design material is intended to give visitors an initial idea of paper as a building material and also display once again the former structure inside the palazzo, which has been reconstructed, because it is now used as an exhibition area.

The exhibits on the walls follow a narrative that shows off the fundamentals and principles that have been developed when building with paper as a material, ranging from simple material compounds to specific architectural projects that have been constructed. From material components to industrial products, visitors are shown newly developed material compounds and components and even specific structures made of paper. The central element at the exhibition is the demonstrator, which can be entered and therefore experienced as the archetype of a house on a scale of 1:1.

Photo for the ECC exhibition catalogue, Oskar Gerspach-Wolf, FGPG 2020.

LOEWE CEPTER: SUCCESS THANKS TO USING ARTIFICIAL INTELLIGENCE IN EPILEPSY RESEARCH

Artificial intelligence (AI) is also becoming increasingly important in medical diagnostics. A team of researchers from the **CePTER (Centre for Personalized Translational Epilepsy Research) LOEWE cluster** has now developed a method for using artificial intelligence to detect epilepsy while it is still developing. This could open up entirely new possibilities for treatment.

Epilepsy is a widespread and, contrary to common belief, common neurological disorder in which the brain's activity goes out of control and causes epileptic attacks. Many people can be relieved of the seizures with medication that is specially tailored to the patients. However, this treatment is ineffective for about 30 percent of those affected. The side-effects of the drugs used are often considerable and are therefore problematic. AI could be useful for treating epilepsy in at least two ways. Firstly, AI algorithms could predict individual seizures. This would allow patients to still stop the car in time, for example, or suppress the attack by taking medication. However, there are currently no reliably functioning systems of this kind, despite years of research. Predicting seizures has so far proved to be as difficult as forecasting earthquakes or volcanic eruptions. That is why the researchers in the **CePTER LOEWE cluster** led by Felix Rosenow and Jochen Triesch have developed a second approach for using artificial intelligence. In this context, it is important to know that epilepsy often develops over months or even years before the first seizure occurs. The researchers therefore wondered whether it would be possible to use AI to detect whether epilepsy is developing on the basis of brain activity, even before spontaneously recurring attacks occur. For this purpose, the research group used an animal model of epilepsy, in which a specific region of a rat's brain was stimulated so that epilepsy occurred a few weeks later. They trained so-called deep neural networks to classify whether brain activity was normal or whether the animal was in an early or late phase of epilepsy development based on brain activity. The neural network mastered the task with a surprisingly high degree of precision.

After the successful test in the animal model, the researchers now want to transfer the results to human beings. Although there is still a long way to go, the scientists are confident that this will be possible in the future using AI.

References: Lu, D., Bauer, S., Neubert, V., Costard, L. S., Rosenow, F. & Triesch, J. (2020, September). Staging Epileptogenesis with Deep Neural Networks. In Proceedings of the 11th ACM International Conference on Bioinformatics, Computational Biology and Health Informatics (pp. 1-10).

Photo caption: In the photo on the right: PhD students from the FIAS (Frankfurt Institute for Advanced Studies), a project partner of CePTER, who are using AI methods to detect the development of epilepsy at an early stage. Photo: LOEWE CePTER/Diyuan Lu, Danilo Batulin.

LOEWE NATURE 4.0 MAKES "WHAT IS INVISIBLE IN NATURE VISIBLE"

Observing nature is a central component in conservation concepts and it enables an ongoing description and evaluation of the state of ecosystems. Nature conservation monitoring programmes allow trained experts to specifically observe what can be perceived in the natural world, for example. However, it is not possible for humans to readily recognize, feel or sense all the processes taking place there. Human beings can only recognise a bat call, a swarm of insects flying around at night or even the way that trees transport water from their roots to their leaves if they use technical aids. The **Nature 4.0 LOEWE cluster** is dedicated to developing precisely these tools in the test region of Marburg Open Forest, the forest at Philipps-University. Sensors developed at the university provide insight into areas of nature that would otherwise remain hidden from humans: by using a networked antenna system and miniature radio transmitters, they are able to study the movement and activity patterns of bats at Marburg Open Forest. The BatRack – a modular observation platform – automatically detects when a bat with a sensor is approaching its roosting place and activates an ultrasonic microphone and a night-vision camera to produce unique video recordings of these hidden animals.

It is well-known from meteorological weather radar data that insects swarming in the air cause interference. This phenomenon is now being used to make flying insects visible in the forest as well. The project uses radar technology from self-driving cars, which is small and mobile enough to enable it to be used locally. Initial pilot studies indicate that flying insects can be detected using the modified radar units and this opens up the potential for an autonomous and non-invasive system for monitoring insect densities.

TreeTalkers – networked, tree-physiological measuring instruments – make it possible to log how more than 50 trees in the study region transport water and nutrients. This will enable the scientists to study the physiological response of forest trees to increasingly frequent droughts and it should help them make general predictions about potential damage to forests in future.

These and other technologies are being brought together in a sensor network in the **Nature 4.0 LOEWE cluster** and combined to provide an overall picture of nature – and its visible as well as invisible sides – thanks to modern data integration.

*In **Marburg Open Forest**, the test region for the Nature 4.0 LOEWE cluster, networked sensor technology makes it possible for scientists to observe nature – both its visible and its invisible sides*

ARE ENVIRONMENTAL CHANGES REFLECTED IN THE GENETIC DIVERSITY OF ANIMALS AND PLANTS?

A lecture by Prof. Dr Steffen Pauls, LOEWE TBG, on Wednesday, 26 May at 7:15 p.m. The genetic makeup of a species allows it to interact perfectly with its environment. But what happens when the environmental conditions change rapidly, as we are already experiencing at this time, and organisms have to respond to this in order to survive? Does adaptation take place quickly enough? And how is it enabled and controlled by genes? The wider the range of genetic possibilities, the more likely that there will be a mix of characteristics that will enable a species to survive in the changing environment. The need to study and protect genetic diversity is perhaps more important now than ever before in the light of global environmental change.

Steffen Pauls is an evolutionary ecologist, the deputy spokesperson of the **TBG LOEWE centre**, the Professor of General Entomology at Justus Liebig University in Giessen and the Head of the Terrestrial Zoology Department at the Senckenberg Research Institute and the Natural History Museum in Frankfurt. The Senckenberg Nature Research Society organises two series of lectures every year. One of them has been running since 17 March 2021 and is entitled "Nature's blueprint – how genomics is revolutionising our view of biodiversity." The lectures are given in digital form every other week on Wednesday evenings starting at 7:15 p.m. For more information on other dates and topics, please visit: www.senckenberg.de/bauplandernatur.

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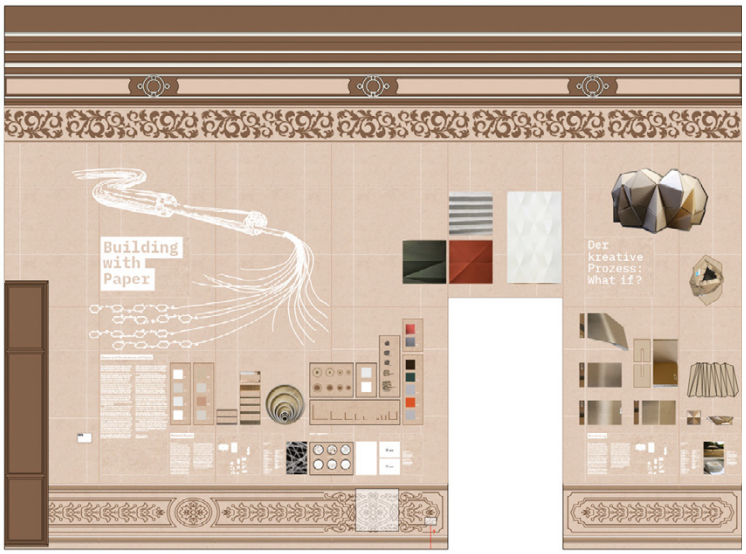
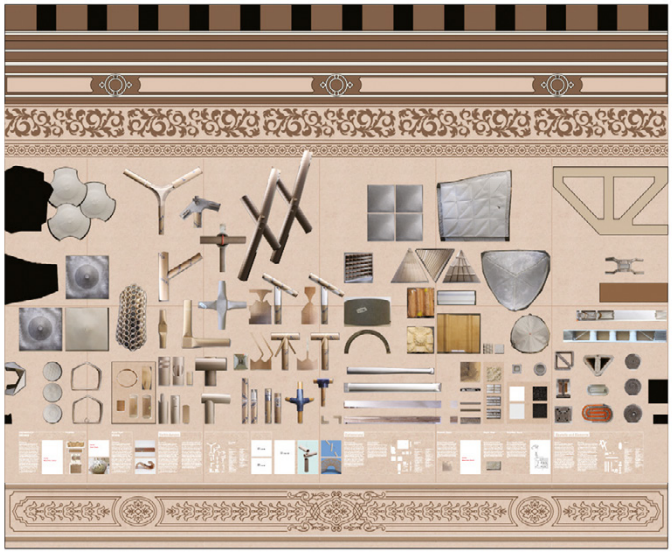
Person in charge: Tanja Desch
Design: designstübchen, Osnabrück
Printing: Grunewald GmbH, Kassel
Picture credits: BAMP! Oskar Gerspach-Wolf und Nina Christl / WhiteBox: Stockfoto / Natur 4.0: Foto: Hessen schafft Wissen – Steffen Böttcher / CePTER: Diyuan Lu und Danilo Batulin / ProLOEWE-Persönlich: Fotografie MD – Mathias Daum

Perspective showroom, Nina Christl, FGPG 2020.



Wall layout at the exhibition – Wall 1, Nina Christl, FGPG 2020.



Wall layout at the exhibition – Wall 2, Nina Christl, FGPG 2020.

Dr Barbarossa is developing mathematical models to help understand and predict the dynamism in the spread of infectious diseases in our globally networked world. Photo: Fotografie MD – Mathias Daum.

Dr Maria Barbarossa
Using mathematics to combat the Covid-19 pandemic

Ms Barbarossa, you have been a fellow and research group leader of the CMMS (Centre of Multiscale Modelling, Analysis and Simulation of Biological Processes) LOEWE cluster at the FIAS in Frankfurt/Main (Frankfurt Institute for Advanced Studies) since 2020. Can you tell us something about your work there? *My group is developing mathematical models and methods to help us understand multiscale processes, i.e. processes that occur on multiple spatial and temporal scales, in immunology and the dynamism of infectious diseases. This means, for example, that we make calculations so that we can predict with a fairly high degree of probability the development and spread of an epidemic. To do this, we combine theoretical approaches with clinical and experimental data. Our current projects are helping us understand homeostasis (equilibrium in many small or large systems), infection and inflammation (e.g. in the newly approved ENABLE cluster), sepsis and systemic inflammation (SCIDATOS, with Heidelberg University), and the spread of COVID-19 and controlling it.*

COVID-19 spread across the world as a pandemic almost at the same time as you started your new job. How has this influenced your work? *Enormously. Even just before I officially started my work in Frankfurt, thanks to the support of the FIAS board and the head of the "Jülich Supercomputing Centre" Thomas Lippert, I was able to start closely cooperating with colleagues from the Jülich Research Centre on the topic of the spread of COVID-19. We have been working on the German data on the pandemic since March 2020. While we initially simulated the effect of non-pharmaceutical control measures (e.g. contact reduction in the population), we are now also working on models of vaccines and virus variants. Our weekly forecasts of cases and death rates are mapped in the German and European forecast hubs. The special thing about what we are doing in this project is our work in real time. This is something completely different from regular mathematics research, but it is incredibly interesting for me and for everyone else involved and we are happy to be able to help with the fight against the pandemic through our work.*

And even though it was impossible to foresee that COVID-19 would dominate my work almost round the clock when I accepted my position, excellent conclusions can be drawn from the findings of the research into the current pandemic for the CMMS project too. In addition, the topic connects very well with my projects on sepsis research. Even though any infection can lead to sepsis, this complication seems more common in patients who suffer greatly through COVID-19.

LOEWE CMMS has set itself the long-term goal of gaining a comprehensive understanding of both simple molecular biological processes and the complex behaviour of organisms. What do you think you can achieve through LOEWE funding, which would not have been possible otherwise? *LOEWE funding provides a great opportunity and allows me and the other scientists to conduct independent research through the financial support. What is also special is the interdisciplinary make-up of the research landscape in Frankfurt; as a result, I was connected to the experimental cooperation partners from the outset. We were therefore able to expand existing research projects and develop new ones, even during the first LOEWE year.*

Read the whole interview at proloewe.de